always follow geographic lines, but is often controlled in its direction by prestige of one route over another, by competition and other artificial influences, the route to the East via Minneapolis and Duluth, or Minneapolis and Chicago, may be justifiable. It has been shown* with regard to rates between the East and the Twin Cities, and also with regard to rates between points in southern North Dakota, South Dakota, southern Minnesota and Minneapolis, and between the same points and Duluth, that the railroads have adjusted their rates in a manner unfair to Duluth.†

As a result of the above conditions, Duluth, though enjoying geographically a location which seems to possess the possibilities of development into one of the world's greatest metropolitan centers, is tremendously handicapped. Until such an adjustment of artificial conditions is made which will be consistent with Duluth's natural environment its growth will necessarily be rather slow.

* "A Memorial *in re* Rail and Lake Rates, July, 1910." The Traffic Commission of the Commercial Club of Duluth.

† Report of Hearing of Duluth Shippers before the Interstate Commerce Commission, *Duluth News-Tribune*, Nov. 23, 1911, and other unpublished data.

(To be concluded.)

THE ILLINOIS PETROLEUM FIELDS

BY

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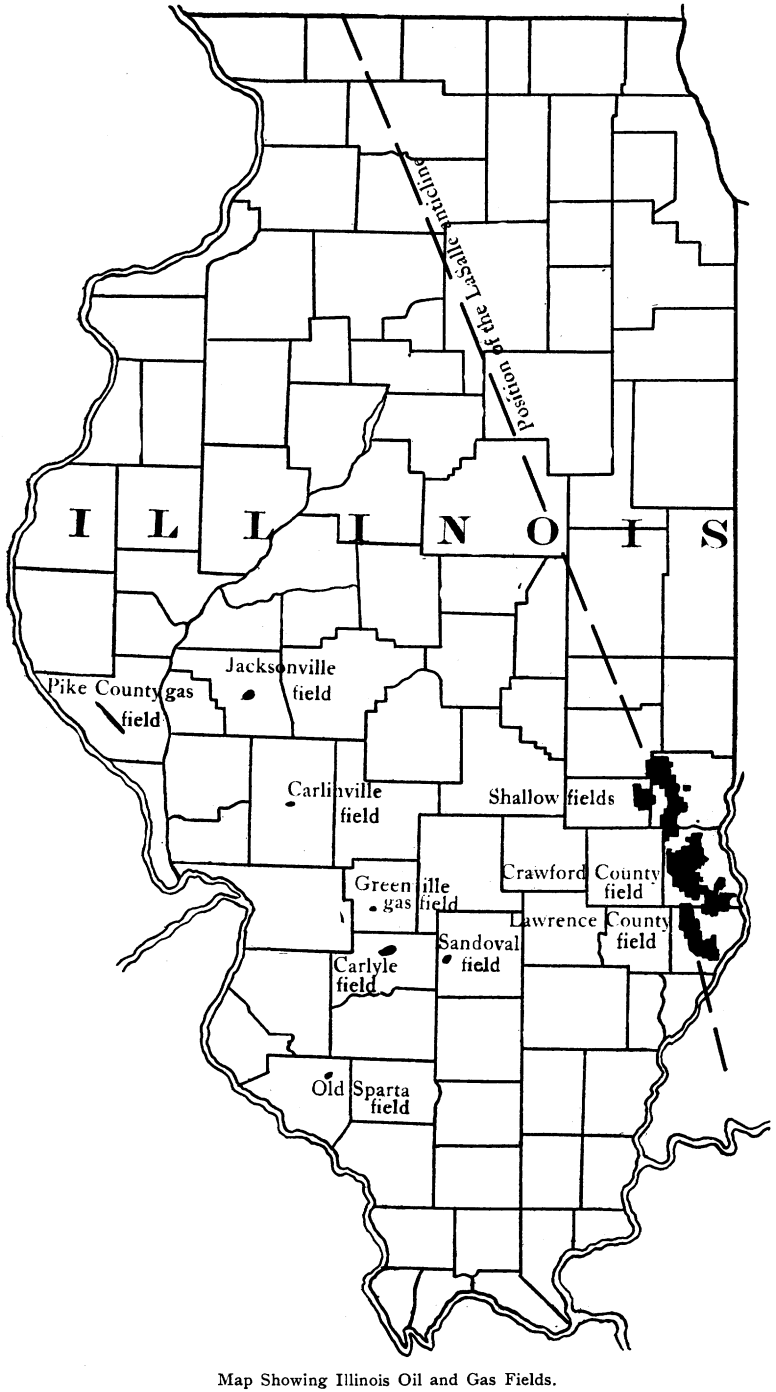
There is no more interesting chapter in the development of American oil fields than that of Illinois. Indeed, its phenomenal growth and rank are unparalleled in this country. Less than eight years ago Illinois was considered unfavorable territory for prospecting because of many unsuccessful attempts to find oil and gas and a prevalent idea that the structure of the State and its relations to the occurrence of oil and gas did not justify the presence of commercial pools. Not only were great fields of high grade petroleum found despite this feeling but also the structure and position of the pools indicate an ideal condition for the accumulation of oil and gas.

Since 1905 about 20,000 wells have been drilled in the State and 85 per cent of these have produced about 158,000,000 barrels of oil valued at $103,000,000. The present annual yield is over 30,000,000 barrels, with a valuation of about $19,000,000.

Position of the Active Fields. The main oil fields, from which most of the production comes, lie in the southeastern part of Illinois close to the Illinois-Indiana state line. They are about 165 miles directly south of Chicago and 125 miles east of St. Louis. The fields are 60 miles long and from one to eight miles wide, with an areal extent of about 250 square miles. They are not continuous but are segregated, by coincidence, into three counties, with small portions overlapping adjoining counties. They are, in order from north to south, the Clark (shallow fields), Crawford, and Lawrence county pools. The field next in importance lies three miles northwest of Carlyle, Clinton County, or about forty-five miles east of St. Louis. The field is two miles long and one mile wide, with an areal extent of two square miles. Another minor field lies one-half mile north of Sandoval, Marion County, or about sixty miles east of St. Louis. It covers about three-fourths of one square mile.

History and Present Condition of the Fields. The earliest recorded attempts to locate oil and gas in Illinois were near Casey in 1865, in the midst of the present Clark County pool. Here several wells were drilled, but the work was abandoned. Oil and gas were found, the importance of which would have been appreciated had better drilling facilities been available. Salt water drowned out the oil and prevented an earlier discovery of the present extensive fields. Between 1865 and 1900 several attempts were made to locate oil and gas. Small pools were found near Litchfield, Pittsfield, and Sparta. These are almost wholly abandoned at the present time.

The earlier drilling in Clark County prompted redrilling in the area near Casey in 1904-1905 and resulted in opening the main fields. The first wells yielded initially about thirty-five barrels of oil per day. The development spread rapidly and gradually merged into the deeper pools of Crawford and Lawrence counties until at the present time the main fields are clearly defined and with the exception of small amounts of inside drilling have ceased development. In general the depth of the wells increases consistently from the north to the south. The fields of Clark, Cumberland, Coles, and Edgar counties are called the "shallow" area because the oil usually comes from two sands at a depth of 350 to 600 feet. Such variability of depth is due to structural features of the rocks rather than



Map Showing Illinois Oil and Gas Fields.

to topographic relief, which is very slight in this section of the State.

The boundaries of the productive field in the shallow area were clearly defined in 1910 and include about 60 square miles. There has been practically no development since then and a great many of the original wells are yielding so poorly, as a result of the rapid drain of the field, that they are being plugged and abandoned. The complete abandonment of the shallow areas is not far distant. The combined daily output of the field is about 8,000 barrels, compared with 9,000 barrels in 1910. The shallow fields have been the most profitable in the State because of their depth and small cost of development and production.

The Crawford County field was opened in 1906 and is the largest of the three general pools. It covers in all about 150 square miles. The southeast end of the pool branches into a spur known as the Flat Rock and Duncanville pools. The latter produces a heavy, fuel oil. The sands of the Crawford County pools range in depth from 725 to 975 feet. There is one general sand made up of three locally parallel lenses, but there are, however, small areas where some of the lenses or even all the sands are absent. The extensive development and drain on this pool has caused a general decline of production. The average daily yield from this area in 1911 was about 18,000 barrels, as against 30,000 barrels in 1910 and 100,000 barrels in 1907.

The Lawrence County field was opened in July, 1906, and has since proven the richest producing area in the State. It is distinctive because there are seven sands from 750 to 1,900 feet deep that yield steadily about 42,000 barrels per day. In order of depth and with local names they are the Bridgeport No. 1, 2, 3 lenses, 750 to 1,000 feet; the Buchanan, 1,100 to 1,400 feet; the Kirkwood, 1,350 to 1,650 feet; the Tracey, 1,550 to 1,750 feet; and the McClosky, 1,750 to 1,900 feet. The Kirkwood and McClosky sands, especially the latter, are the richest developed in Illinois. The Lawrence County field covers about forty square miles, and within this area there has been developed a greater per cent. of large wells than in all of the other pools combined. Some of the wells reach an initial production of 2,000 barrels per day, and maintain as high as 1,000 barrels daily for several months after shooting.

With the gradual decline of operations in the main field came the desire for new pools. Wildcatting in Marion County resulted in the development of a small field near Sandoval in 1909-1910, which was

clearly defined in 1911. The oil comes from a sand 1,520 to 1,600 feet deep that is the equivalent of the Kirkwood sand of Lawrence County. There are about 70 producing wells yielding 1,800 barrels per day.

An excellent field was tapped in April, 1911, about three miles northwest of Carlyle, Clinton County. The area was described and recommended by the State Geological Survey* previous to the drilling. The producing sand lies at a depth of about 1,030 feet and is thought to be the stratigraphic equivalent of the Kirkwood sand. The field is governed by an elongated dome on the western flank of the Illinois basin and includes over 125 wells, with a daily yield of about 4,500 barrels.

Production. The total amount of oil produced in Illinois previous to 1905 is negligible compared to the present annual yield. About 98 per cent. of the oil has been refined, while the remaining two per cent. has been sold for fuel. All of the Illinois oils have a paraffine base.

Up to January 1, 1912, about 19,982 wells had been drilled for oil and gas in the State, of which 3,152, or 15.7 per cent., were barren and 16,830, or 84.3 per cent., yielded the following production and value as recorded at the close of 1911:

ILLINOIS OIL PRODUCTION TO 1912

YEAR	BARRELS	VALUE
Previous to 1905	6,576	.....
1905	181,084	$116,561
1906	4,397,050	3,274,818
1907	24,281,973	16,432,947
1908	33,686,238	22,649,561
1909	30,898,339	19,788,864
1910	33,143,362	19,669,383
1911 (estimated)	30,000,000	19,500,000
	156,594,622	$101,432,134

Illinois gained ninth place in production and value of oil in 1906 and third place for both in 1907. Since then the State has held third place for production and second for value and has been excelled only by California and Oklahoma. The rapid attainment of such rank among oil producing States of the Union in three years is remarkable when it is considered that other great American fields, and most of them much more extensive, required twenty or more years to attain similar positions.

There have been two declines in the brief history of the oil business in Illinois. The first came in 1909 and was due to disturbed

* Blatchley, R. S., Ill. State Geol. Survey, *Bull.* No. 16, pp. 87 and 167.

market conditions. Recovery was prompt in 1910, but in 1911 continued decline of the early fields and the lack of new development in the later pools caused a second reversal. Unless new fields are discovered the decline must continue.

Prices. All Illinois oil sold at one price varying from 60 to 83 cents per barrel from 1905 to 1907, inclusive. A grading and division in price took place in 1908. The better grades of oil have a gravity between 30° and 37° Beaume, while that of the Duncanville pool lies between 22° and 24°. The development of the Tracey and McClosky sands of Lawrence County gave still higher grades of petroleum varying from 35° to 39°. The difference of gravity necessarily caused a division of price, with the dividing line at 30°. The prevailing price now is 83 cents for oil above 30° and 73 cents for oil below that figure. The continued increase of prices is an inducement for active work in outlying districts where there is hope of finding new fields.

The Ohio Oil Company or producing agent of the Standard Oil Company developed about 40 per cent. of the Illinois fields and with purchased properties now controls 75 per cent. of the total development. This company buys and stores more than 90 per cent. of the oil of the State.

Field Efficiency. The Illinois field is one of the best equipped in the world. There has never been a field of such proportions so well cared for in such a brief period of time. Through the efforts of the Ohio Oil Company, a very efficient system of collecting oil from most of the field by gravity lines has been established. Advantage is taken of the slope of the streams along which the lines are laid after being connected with each lease. The oil flows by its own weight down the lines to a substation where it is caught and pumped back to Martinsville, Ill., and from thence overland, through three pipe lines, to Lima, O. This system has furnished a very profitable saving over the old donkey pump method. The phenomenal growth of the fields necessitated a systematic storage of surplus oil in conjunction with the pipe-line system. Tank farms with over 490 tanks, each of 35,000 barrels capacity, are conveniently located. In order to further systematize the handling of such a field, this same company maintains excellent survey, discharge, and telegraph departments which are in constant touch with the whole field. By this management less than 3 per cent of the oil is lost and that results naturally from evaporation, sediment, and leakage.

The region about the oil fields has been greatly benefited by their

development. The territory first underwent a boom and for a period of several years became a frontier. The activity and rush were similar to that of a new gold strike. Old towns enlarged quickly and new ones sprang up within a very short time. The development added wealth to the community which found its way into improvement of the towns. New schools, paved streets, stores, better dwellings, etc., have taken the place of the once lethargic condition of a mediocre agricultural district. Over $20,000,000 from royalties alone and perhaps a similar amount for bonuses, labor, etc., not to speak of land valuations, have been left to the landowners.

Geology. In order that the reader may have a general view of the oil and gas conditions of the Illinois fields a brief, elementary review of the geology and origin of the oil is presented. The most conspicuous rocks over Illinois are the Pennsylvanian ("Coal Measures") series of the Carboniferous system or those characterized by coals interlain with shales, thin limestones and sands. They occupy 42,000 square miles in the heart of the State. The oil sands of Clark, Cumberland, and Crawford counties occur in this series. The shallow sands lie high in the Pennsylvanian, while the producing sand of Crawford County belongs in the top of the Pottsville rocks or basal sandstones of this series.

The lenticular Bridgeport sands and the Buchanan sand of Lawrence county belong to the Pennsylvanian. The Bridgeport sand of this county and the Robinson sand of Crawford County are considered in the same horizon, as both of them lie at the top of the massive Pottsville rocks.

The Mississippian ("Sub-Carboniferous") rocks underlie the Pennsylvanian and contain the richest sands of the State. They outcrop around the southern and western borders of the State and are thickest in the southern area, but wedge out to the north. They are penetrated about 475 feet in the main fields and include the "Gas" and Kirkwood sands in the Chester rocks at the top of the series; the Tracey sand of the Cypress or Pre-Chester rocks; and the McClosky sand of the Ste. Génévieve. The latter is a soft oolitic limestone overlying a great thickness of hard limestones comprising the major portion of the Mississippian series. This limestone is the most prolific oil horizon in Illinois because of initial flow and steady yield. The Kirkwood sand is the most widespread producing horizon in Illinois. It is correlated with the Carlyle sand of Clinton County, the Benoist sand of the Sandoval field, Marion County, the Sparta sand of Randolph County, and the Oakland City sand of Pike County, Indiana.

General Structure of the State, A number of cross-sections* across Illinois, compiled from well borings and mines, indicate that the central and southern portion of the State lies within a great spoon-shaped basin with its long axis extending from the Wisconsin State line in Stephenson County past LaSalle, Cerro Gordo, Lovington, Olney and into the deepest part of the basin in Wayne, Hamilton, Edwards, and White counties. Towards this basin, with local exceptions, all the rocks of Illinois and of western Indiana dip gently. The rocks on the eastern side of the basin rise rapidly into a conspicuous fold known as the LaSalle anticline, decline gently and then rise again into Indiana. The anticline is exposed in river bluffs near LaSalle and passes from thence in a southeastward direction to Sadorous in Champaign County, past Tuscola and enters the main oil fields of Clark County near Westfield. It continues in a direct line through the oil fields and apparently crosses the Wabash and continues to Princeton, Indiana. The western side of the basin is very gentle and is occasionally interrupted by small deformations such as terraces or domes, along which pools of oil or gas have accumulated.

Probable Origin of Illinois Oil. During the deposition of the sedimentary rocks in the Illinois basin a great abundance of plant life, both marine and land, was laid down with the muds and silts of the accumulating deposits of centuries. These, with possibly some marine animal life, were shut off from the oxygen of the air and other destructive agents and were trapped within the shale deposits, where eventually, through the lapse of geologic time, a peculiar, slow distillation took place, wherein the protoplasm, carbon, and other constituents of the once living matter were converted into oils and gases. The distillation was a matter of ages and its subsequent migration from the shales or limestones to more porous reservoirs by means of capillarity, gravity, and gas or rock pressure was accomplished in additional periods of time. It is thought that the natural distillation of the petroleum and a great portion of its migration to the sands took place while the beds lay horizontal or practically so. There was subsequent folding of the strata which formed the extensive LaSalle anticline along the eastern side and the wrinkling into terraces and domes along the broad, gentle western slope of the Illinois basin. When these disturbances occurred the water, petroleum, and gas within the sandstones were forced to move according to their specific gravities. The water sought the basin, while the oil

* Loc. cit., Plates 7 to 11.

and gas were displaced and forced into the crest of the LaSalle fold on the east and into the small irregular domes and terraces on the west.

It is thought that those oils that have small per cent. of sulphur and are sweet smelling originated from the plant life of the shales, while the oils of large sulphur content and very rank odors came from marine animal life of the limestones. The former oils are found in pure sands, while the latter come from limestones or highly calcareous sandstones.

Results of Geologic Investigation. An investigation of the geological conditions of the main fields was recently made with a view of determining the cause of the accumulation of oil and gas and the relation of the quantities of oil, gas, salt water, porosity of the sand, etc., to the structural features of the sand. The work was based upon the elevations and records of 5,200 wells in the southern half of Crawford and the whole of Lawrence counties.

The Illinois basin and the lower flanks of the LaSalle anticline yield abundant water in all of the productive sands of the main fields. The western limits of the fields are clearly defined and beyond this line the sands are wholly water-bearing, while over the fold most of the sands are oil or gas bearing. It is obvious from the position of the water and oil along the LaSalle anticline that the water has controlled the accumulation of oil in the fold. The water probably has originally permitted the oil to migrate long distances up the slope of the Illinois basin into the arch.

The accumulation of oil and gas in their present position may be looked upon as ideal and is presumably due to the following factors:

1. There is an extensive anticline, with a marked basin on at least one side.

2. The depressions on both sides of the fold, showing abundant water, comprise extensive "feeding" areas for the accumulation of oil in the arch.

3. The sands are commonly porous and hence form suitable reservoirs.

4. There are abundant shales and some limestones overlying the sandstones, which probably serve as impervious covers to the reservoirs.

5. The sands in both limbs of the anticline are abundantly saturated with salt water, which is probably instrumental, by difference in gravity, in holding the oil and gas captive in its present position.

6. Although the general structure of the oil fields is dominated

by a major fold its crest is very irregular and is interrupted by numerous minor domes and transverse depressions, which, together with irregularities of porosity, have been instrumental in segregating the pools.

7. With one exception the best collection of oil was found over the broad flat areas. The domes over the entire field are logical gas reservoirs; but, contrary to expectation, the largest amounts of gas and oil do not lie at the apexes of the domes but a short distance below.

Natural Gas. Illinois produces small amounts of natural gas in proportion to her immense quantities of petroleum. Her present annual yield has a value of about $600,000 and a rank of eighth among gas producing states. The total value of gas produced in Illinois from 1885 to 1911 is about $2,649,000. The principal gas areas of the State lie within the main fields near Bellair and Hardinville, Crawford County, and north of Bridgeport, Lawrence County. The gas comes from raised portions of the oil horizon. Many of the oil wells produce small quantities of gas which is used, chiefly, for field operations. There are about forty gas wells that supply towns within or close to the oil fields. Gas is found in less commercial quantities at other points in the State, such as Sandoval, Greenville, Carlyle, Carlinville and Jacksonville.

THE TRANSCONTINENTAL EXCURSION OF THE AMERICAN GEOGRAPHICAL SOCIETY

As the *Bulletin* has already announced, the American Geographical Society of New York celebrates this year the sixtieth anniversary of its founding and the occupation of its new building on Broadway at 156th Street. No form of celebration seemed so fitting as an excursion across the United States, in which an invited party of European geographers should make the journey in company with a number of American geographers, who would show the visitors the most significant of our geographical features, the excursion to be closed by a meeting in New York, when the visitors should be invited to give some account of what they had seen.

The plan thus outlined is now approaching its realization. The